STRATA

Method Statement for Design and Construction Of Reinforced Soil Walls with StrataWall™ EC Panels and StrataStrip™ Geogrids

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I. StrataWall™ EC System – A Preamble

Innovation has been the key word at Strata, and we are obsessed with the objective of continuously upgrading our systems. We are committed to provide economic but safe solutions to our esteemed clients. All along, conservation of the environment has always been well within our sights. We have optimized the connection between the StrataWall™ precast concrete panel to develop the StrataWall™ EC System.
This document highlights salient essential aspects of constructing the reinforced soil systems with StrataWall™ EC panel. Along with StrataStrip™ polyester (PET) soil reinforcement.

Fig 1: EC structure Image.

A. Concept of Reinforced Soil

- Reinforced Soil is a composite material formed by the frictional interaction between selected soil and Geogrids. The reinforcing geogrids resist stresses produced within the soil mass; stresses are transferred to the geogrids via friction.

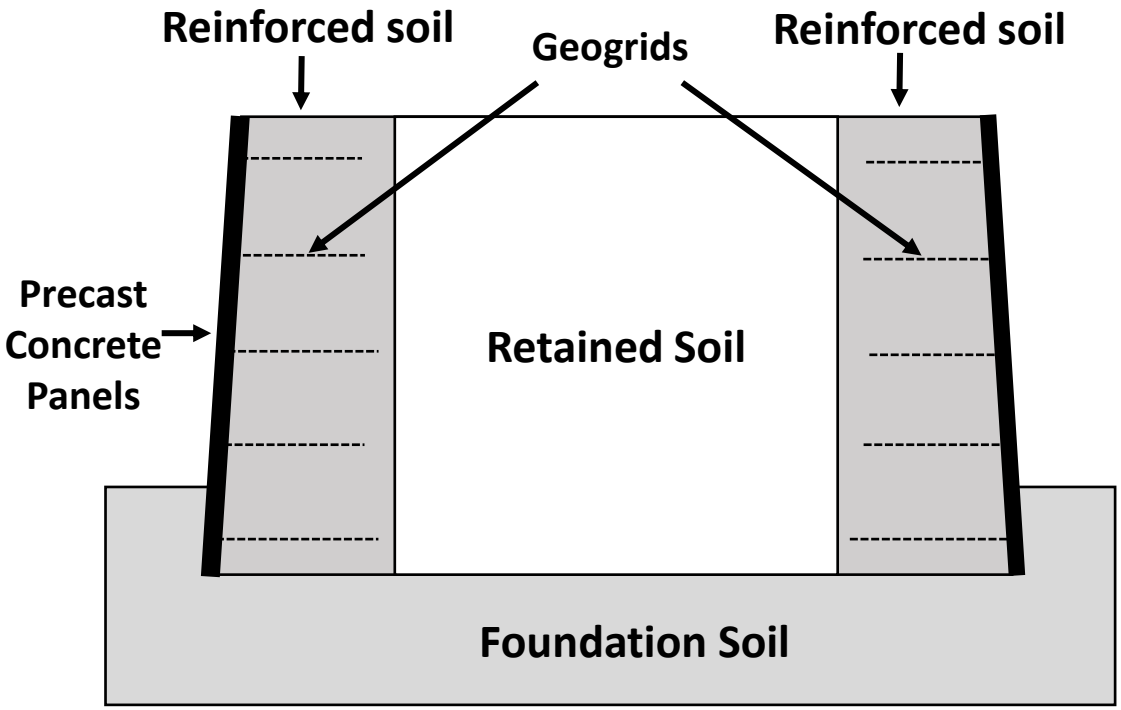

Fig 2.1: Cross section of a Reinforced Soil Wall

- StrataWall™ EC is a Concrete panel-faced reinforced soil wall system. The granular backfill is reinforced with StrataStrip™ Geogrids to create an internally stabilized mass of reinforced soil which withstands both static as well as dynamic loads. This system consists of StrataStrip Geogrids (up to 200 mm width), StrataConnect connectors (more robust than any alternative in the market), and precast concrete panels. StrataStrip is positively connected to the panel by passing it through StrataConnect embedded connectors which create a cavity in the concrete panel.

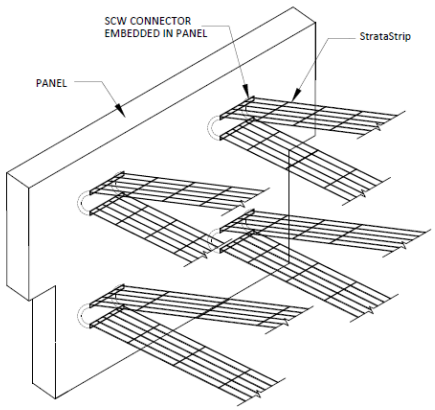

Fig 2.2: Technical drawing of StrataWall EC

B. Components
Reinforced Earth structures consist of the following:

Concrete Levelling Pad: A unreinforced Concrete leveling pad serves as a smooth, level surface for placing panels. Generally this is a M-15 grade lean concrete 150mm in depth and 400mm width or as stated in the engineering drawing.

Fig. 2.3: Levelling Pad

Fascia Panels: The panels are the outermost face of the reinforced soil structure. Their essential objective is to protect the structure backfill material from erosion. Since the panels are essentially the exteriors of a reinforced soil system, they also require to serve an aesthetic purpose and these precast panels often have an embossed surface as per the client's requirements. These panels can either be manufactured at a precast facility or cast at project site using metallic / wooden moulds.
Metallic moulds may be provided by Strata on request for standard shapes.

Fig. 2.4: Panel Fascia

Spacers: EPDM bearing pads are placed in the horizontal joints throughout the structure to prevent concrete to concrete contact. Correction pads are used wherever needed to adjust for minor variations in panel height.
This may be provided by Strata on request.

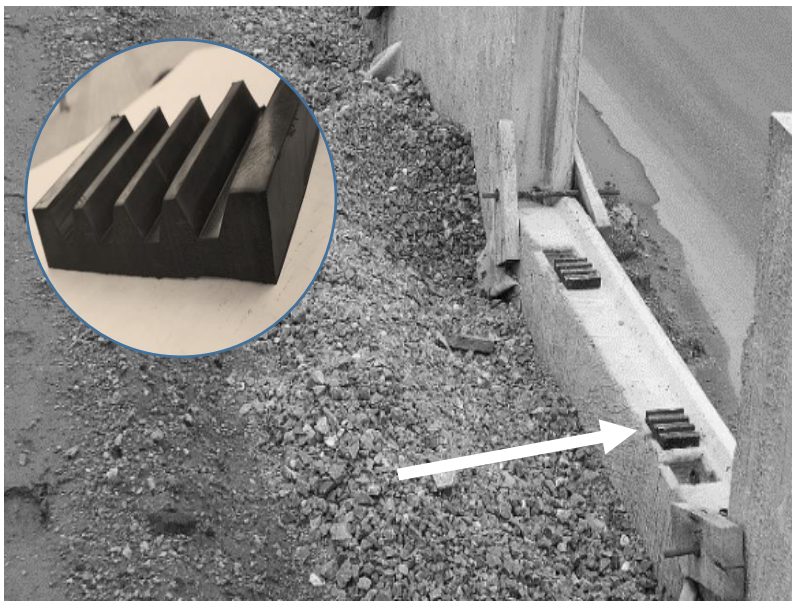

Fig 2.5: Spacers between the Panels

Filtration Fabric: Generally, a non-woven geotextile filtration fabric used for covering the joints between the panels. This is done for prevention of soil erosion through the joints and only allow water to flow out from the wall.
This may be provided by Strata on request.

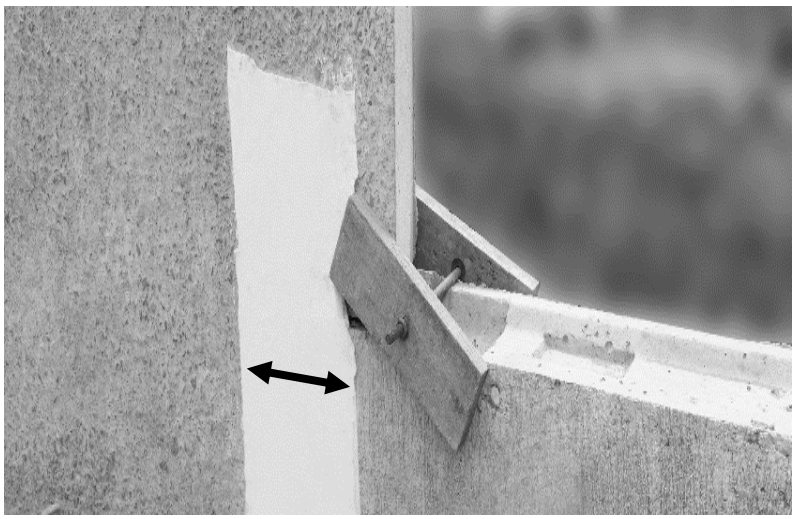

Fig 2.6: Filtration Fabric

Reinforcement - StrataStrip™: StrataStrip™ is a specially designed reinforcement strip made from high tenacity Polyester yarns and coated with a proprietary saturation coating. They are manufactured in 2 sizes – 100mm (4") and 200mm (8") width with varying ultimate strengths. Their Primary objective is to hold the backfill material in position. The tension developed in the reinforcement by virtue of the soil-reinforcement interaction holds the backfill material along with the surcharge loads that the system is designed for. Besides this, the reinforcement also holds the fascia panel in position through the connection.

Fig 2.7: StrataStrip™

Fascia Connectors – StrataConnect™: Connector system central to the StrataWall™ EC panel system. It comprises of a specially profiled device fabricated from a polymeric material. It is essentially a tubular component which creates a C-shaped cavity in the concrete panel. StrataConnect™ is designed to allow easy access for the StrataStrip™ reinforcement. StrataConnect™ comes in two different sizes – StrataConnect Wide (SCW) and StrataConnect Narrow (SCN) to suit different strength requirements.

Fig. 2.8: SC Connectors with their openings sealed with tape

Filter Medium : Self-compacting gravel, minimum 300mm thick placed immediately behind the precast concrete fascia panels. Being self-compacting, the material helps avoid heavy compaction near the precast concrete panels placed in position to line and length without disturbing them. The material also primarily serves as a transition for the polymeric soil reinforcement between the panel connection where the vertical deformation is low, and the reinforced backfill which is flexible and subject to vertical deformations. Also being high permeability material Filter medium routes any water ingress to harmlessly seep out of the system.
This component is site specific.

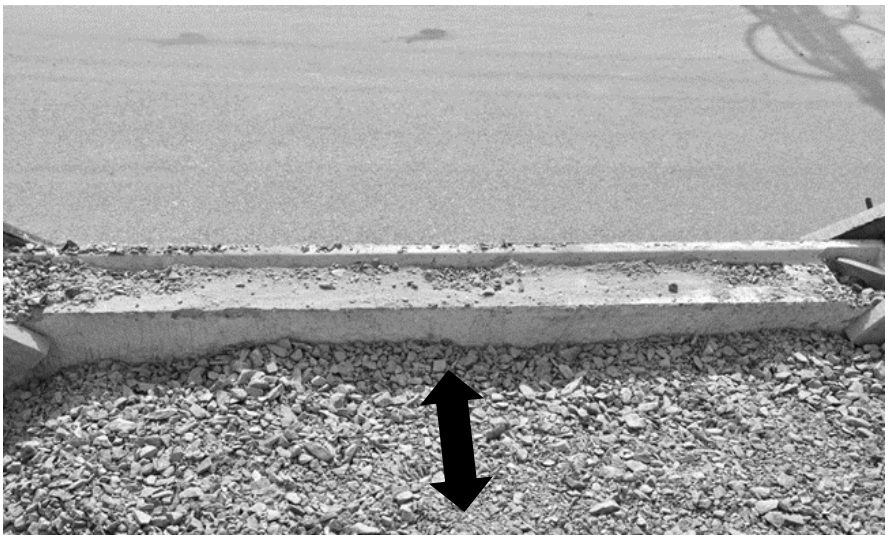

Fig. 2.9: Filter Medium adjacent to the Panel fascia

Wedges: When backfilling / compaction is carried out behind the panels, the panels will tend to shift from the set alignment. It can be difficult due to certain constraints to provide support systems along the exterior. Timber wedges typically made of soft wood (or any locally available wood used in shuttering) are used to hold the panels in position and ensure that they maintain the correct line and batter.
This may be provided by Strata on request.

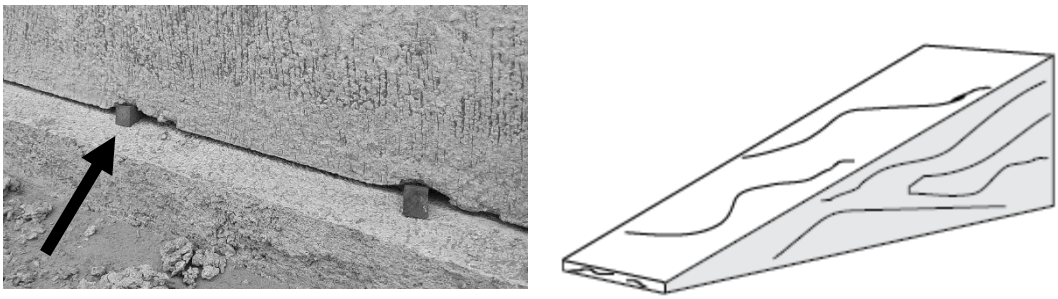

Fig. 2.10: Wooden wedges used for alignment

Wooden Clamps : Paddings made from quality timber for holding the panel positioning jacks in position.
This may be provided by Strata on request.

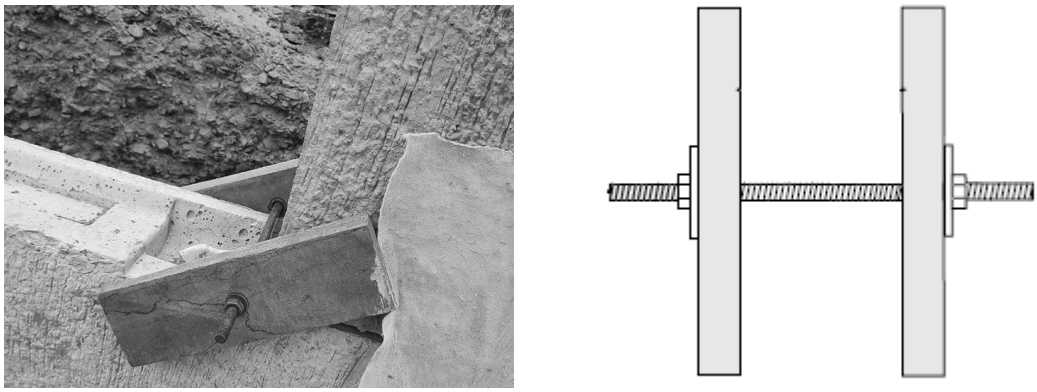

Fig. 2.11: Wooden clamps

Lifting Slings: Slings are used to lift the fascia panels from the moulds after achieving sufficient strength and for all handling purposes.
This may be provided by Strata on request.

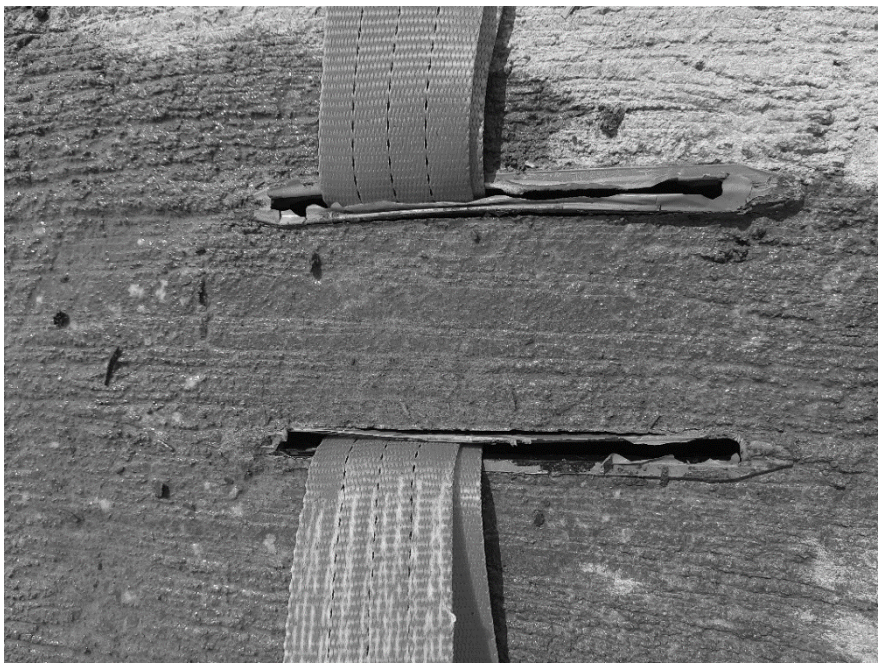

Fig. 2.12: Lifting Slings

C. Designing the StrataWall™ EC System:

The Designs of StrataWall™ EC system can be provided by Strata on request as per the International standards such as FHWA, BS, EURO Codes, IRC, and others. All StrataWall structures are designed by specialist geotechnical engineers using globally recognized software / systems. Strata can provide full design packages from reviewing survey / GAD information, performing foundation checks, providing designs and full layout drawings. These designs can be easily verified and approved by any Professional Engineer.

StrataWall™ EC panels are precast reinforced concrete systems which shall be designed accordingly as per the relevant codes of practice prevalent in the country where the project is being implemented.

The concrete mix shall conform to better than M35 (cube strength of 35N/mm2). Reinforcement shall be ribbed steel bars of Grade Fe500 or better, depending on availability at the project site.

3. Casting the StrataWall™ EC Panels

StrataWall™ EC panels are manufactured in a precast facility or a project dedicated casting yard. In both cases, strict quality control is to be observed to ensure a quality product which is essential for structure performance and aesthetics. In a nutshell, the following are the essentials for casting the StrataWall™ EC panels:

1. Quality concrete to grade equal to or better than the specified grade.
2. Reinforcement as specified by the designer including placement and cover.
3. Proper Placement and alignment of connector system embedded in the concrete panel.
4. All locational and dimensions to be within the specified tolerances.

A. PREPARATION FOR CASTING

Plan for the moulds

Invariably, the panels will be cast with supply of concrete either directly from a concrete truck mixer or a hose direct from a concrete pump or a concrete placement boom. Plan for several casting moulds considering the quantity of concrete that can be supplied at a time, it is necessary to plan for several casting moulds

Platform for Moulds

If casting at project site, a platform shall be constructed at a convenient height to support the line of moulds. The platform shall be firm and should be immovable under normal impact expected during construction. The surface of the platform shall be perfectly horizontal level to receive the casting moulds. A typical setup comprising precast poles is shown in Fig 3.1.

Ensure a levelled platform which is crucial for proper casting of the panels.

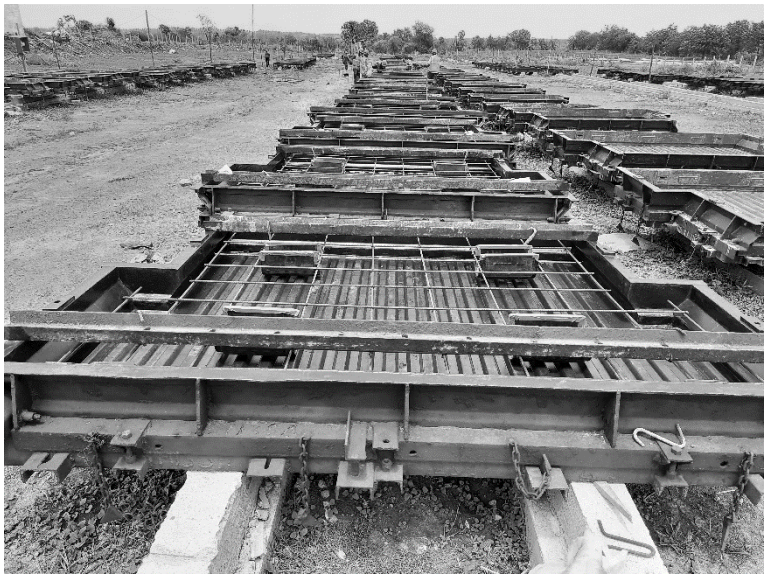

Fig. 3.1: Mould Closeup

Check the Inner Dimensions

The shape and inner dimensions of the mould shall be checked to ensure that they match the dimensions required for the corresponding panel type.

Preparation of the moulds

- Various components of the mould shall not be dented or disfigured in any way.
- The inner surface of the moulds shall be cleaned and rendered free off any debris of the previous cast, rust, excessive mould oil, etc.
- Care shall be taken to ensure The mould shall be assembled by fastening the bolts and nuts, while simultaneously checking and cross-checking the inner dimensions to a tolerance of ±2mm that the panel pattern at the base of the mould is not deformed and cleared of any debris.
- The pattern shall be cleaned with mould oil.

Proper fixing of the moulds while simultaneously checking and cross-checking the inner dimensions is crucial for achieving Panels as per the required Quality.

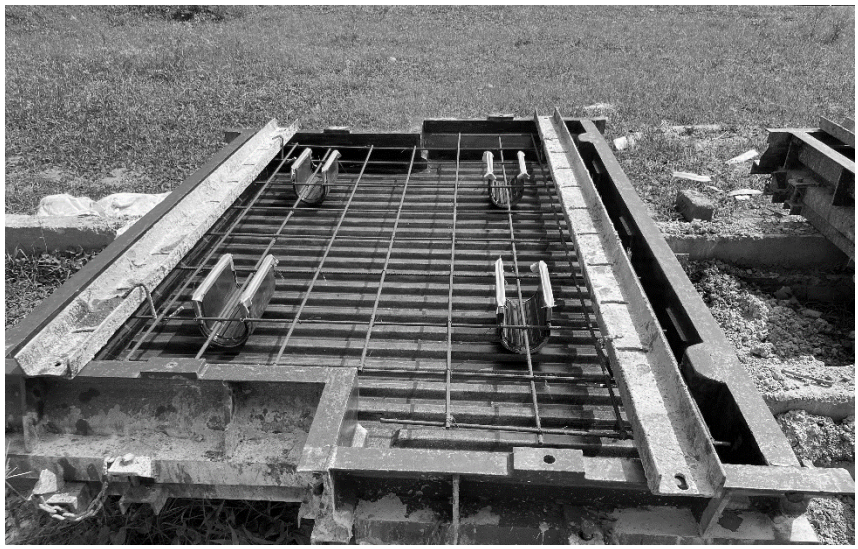

Fig. 3.2: Assembled Mould

Placing Moulds on Platform

- The assembled mould shall be placed perfectly level on the platform to ensure that the front and rear faces of the panel are parallel. This will also ensure uniform thickness of the panel.
- The level of the bottom of the mould shall be checked by a spirit level along several orientations to ensure that the bottom plate is horizontal. This shall be supplemented with checks at the corners of the mould with a water level tube. Shims firmly placed may be used to level the moulds.
- Once aligned, the assembled mould shall be fixed into position to maintain its position and level while placing the reinforcement and connectors, and while pouring the concrete. Fig. shows an example of a mould for a StrataWall™ EC T-panel with reinforcement in place.

Fixing of Reinforcement and StrataConnect™

The SC Connector inserts shall be placed in position within the assembled cage and tied to the vertical bars with binding wire. Locations of these inserts shall be checked strictly in relation to each other and the locational tolerance shall not exceed ±2mm. Cavity openings of SC Connectors should be closed and opened only after concreting

Tolerance checks for reinforcement and SC Connector position as a requirement of QC are illustrated in Fig 3.3.

Ensure correct positioning and fixing of Connector also observe the cleaned ribbing of the mould that would form the panel front face.

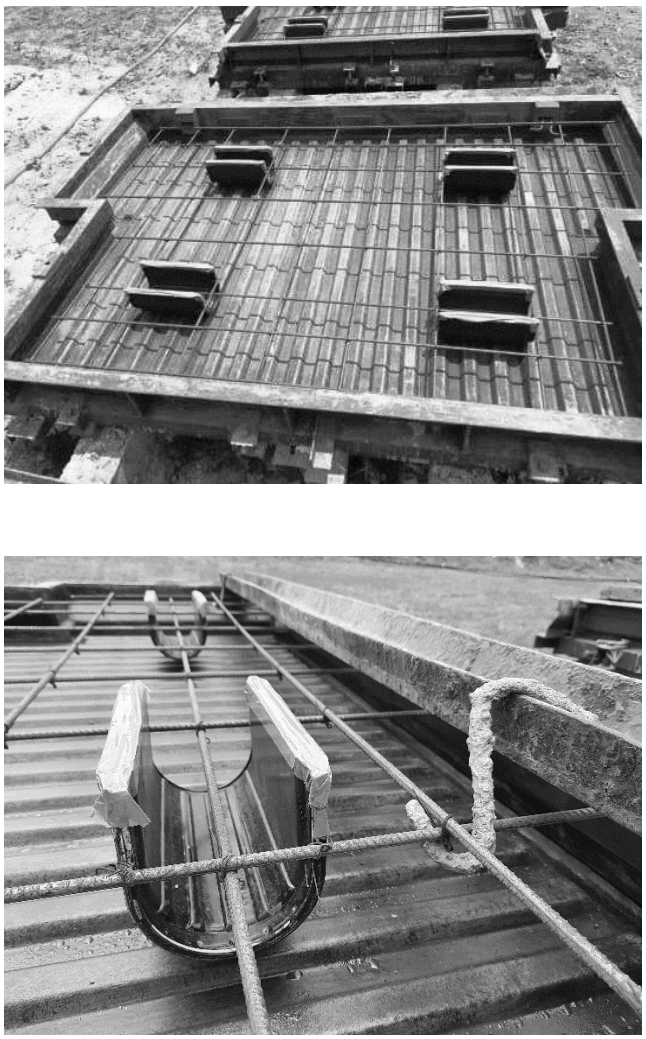

Fig 3.3: The complete assemblage of reinforcement and SC connectors with opening sealed with tapes

B. CHECKS BEFORE CASTING

1. Each StrataWall™ EC panel shall be uniquely nomenclated in a simple manner, as decided by the Design Office or the Project Manager.
2. A pour card shall be maintained for each mould with the standard check list, including for SC Connectors.
3. As an essential preparation prior to placing the concrete, there shall be a final check to ensure the level of the mould bottom plate and the dimensional integrity of location of the bars and of the StrataConnect™ Connectors. The check shall not be cursory but rigorous and accordingly, entries shall be maintained in the pour card for each mould.
4. The grade of concrete shall be as per the Drawing. However, the preferred grade of concrete shall better M35 or M40. The water cement ratio shall be the minimum with approved additives to maintain the slump according to the method of concrete placement. Relevant entries in the pour card for each mould is mandatory.
5. Standard methods of placement and the selection of the method will depend inter alia upon the economics of the operation, availability of equipment, confidence in the skills of the operator in attendance, and space and congestion in and around the casting yard. Fig. 3.4 shows a pour direct from a Transit Miller, a commonly adopted procedure in India

Fig 3.4: Concrete placement directly from Transit miller

6. Special care needs to be taken while compacting the concrete, particularly in the vicinity of the SC connectors. It must be ensured that the connectors are not displaced and if needle vibrators are used, they do not come in contact with the connectors. Even though the SC Connector opening may be protected / taped, it must be ensured that concrete or its slurry does not enter the connector cavity. (in box) It is essential to provide compaction around the connectors to provide maximum strength.

Take necessary precautions ensure Connectors are in place and properly protected.

Fig 3.5: Concrete Compaction using a Needle Vibrator

7. The placed concrete shall be troweled smooth as shown in Fig.11. Thereafter the rear surface will be given a rough finish with wire brushes. The rough finish is seen in Fig. 3.6.

Fig 3.6: Concrete surface troweling

C. PLACING CONCRETE

1. Standard methods of placement and the selection of the method will depend inter alia upon the economics of the operation, availability of equipment, confidence in the skills of the operator in attendance, and space and congestion in and around the casting yard. Fig. 3.8 shows a pour direct from a truck mixer, a commonly adopted procedure in India

Fig. 3.8 : Concrete placement from a Transit Miller

2. Tapes protecting the cavities of the SC connectors shall be removed 6 hours after casting. The cavities shall be rendered clean as seen in Fig. 3.9

Fig. 3.9: After removing the tapes from SC Connectors

3. The casts are maintained as shown in Fig. 3.10

Fig. 3.10: Cast panels in moulds in casting line about 16 hours after casting and SC connector cavity covering tapes will be progressively removed

4. The cast panels shall be left undisturbed in the casting to ensure initial set for 16 hours or as per the design mix, and that the concrete gains adequate strength to be lifted and transported for curing. After 16 hours, the cavity of the SC connectors shall be removed with care, ensuring that the concrete is not spalled in the process.

5. Thereafter, the mould shall be struck with care to ensure that the concrete is not spalled at the corner and edges as seen in in Fig. 3.11.

Fig. 3.11: Moulds Stuck with care

6. The EC panel after striking is seen in the above fig.3.11
7. Further dimensional checks are carried out.

1. Thereafter, lifting straps shall be placed through the SC Connector cavity as seen in Fig. 3.12.

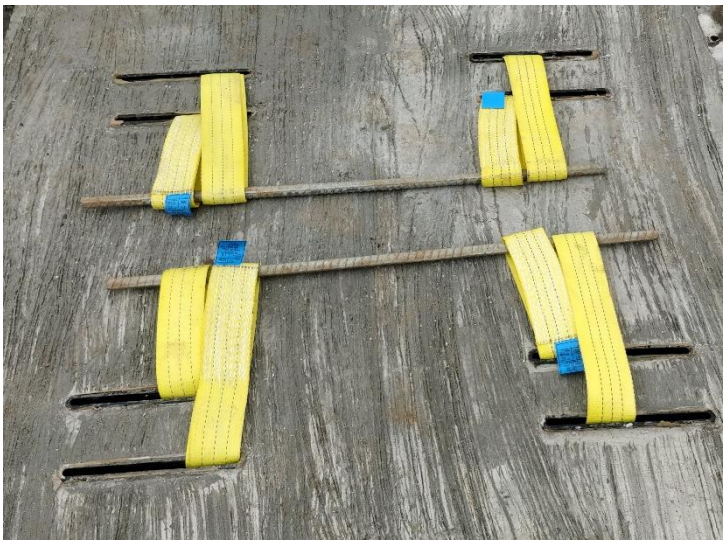

Fig. 3.12: Lifting straps placed through the SC Connector cavity

2. The panels are lifted with an overhead crane or a low capacity tyre mounted mobile crane (Fig. 3.13) and carried to the area designated for curing.

Fig. 3.13: Shifting of Panels for curing

3. The panels shall be covered with nonwoven textile (Fig. 3.14) and sprayed regularly with water or through steam curing

Fig. 3.14: Curing of Panels

5. Erection of StrataWall™ EU System:

At the very outset, approved "Good for Construction" drawings shall be made available and documented at the Project site. Henceforth, such drawings shall be referred to as "Drawing".
The applicator assigned for the RS structure construction shall ensure and satisfy itself that the stockpile for backfill as well as the backfill conforms with the criteria set down by the designer in the Drawings.

A. Construction Equipment

In view of polymeric soil reinforcement being used, no tracked equipment / vehicle shall be allowed at the project site. All equipment shall be rubber-tyred. The following minimum equipment are recommended. The number of each to be mobilised will depend on the quantum of work, schedules, lead distances etc.

- Dozer and / or back-hoe (JCB);
- Cranes with long boom;
- Hydra crane;
- Mechanised hand tampers;
- 8 Tonne capacity vibratory rollers;
- Earth movers / dumpers.

It is to be noted that no equipment is to be allowed directly on laid out StrataStrip™.

There shall be a soil layer of at least 100mm over the reinforcement before any equipment can move over the reinforcement.

B. Site Preparation

Site preparation includes the conventional grubbing and levelling activities.

The alignment of the structure shall be carefully laid out, taking due cognizance of the required carriageway width and alignment at the top of the structure, and the designed batter of the StrataWall™ EC fascia.

C. Foundation Preparation

1. Excavation of the dressed ground shall commence by mechanical means to the foundation level indicated on the Drawing 5.1.

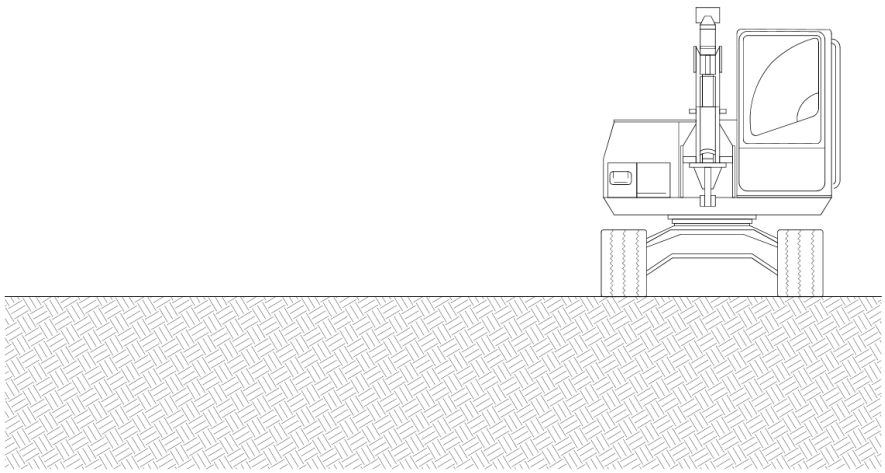

Fig. 5.1 Excavation to the foundation level

2. The base of the excavation which will be the founding level of the structure shall be closely examined and checked out for pockets of loose / soft material. Such pockets shall be thoroughly removed off the inadequate material. The ensuing excavation shall be dressed such that it can receive and facilitate proper compaction within. The pocket shall be filled and compacted according to standard compaction norms, preferably with the soil matrix material. Only in specific approved cases, such excavation shall be filled with lean concrete or similar stiff material. This is to ensure that there is no sudden change in the stiffness of the founding material.

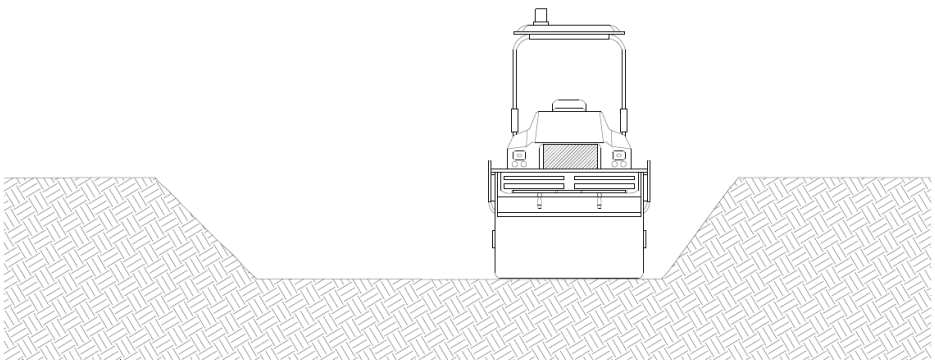

Fig. 5.2 Excavated area being compacted

3. If the soil at the subgrade level is weak, the designer shall recommend one of the ground improvement techniques or soil replacement to a practical depth. There shall be close interaction between site and the design office on this account.

4. The subgrade shall be rendered smooth and all loose debris shall be removed. The levels shall be according to the Drawing.

D. Levelling Pad

1. Locations for slip joints shall be clearly demarcated as per the Drawings. The slip joint shall extend into the levelling pad. It may be noted that the designer may locate the slip joint at change of level of the foundation requiring a step. Such a step may be cast of M15 grade plain cement concrete and the slip joint detailing shall be particularly noted at that location.

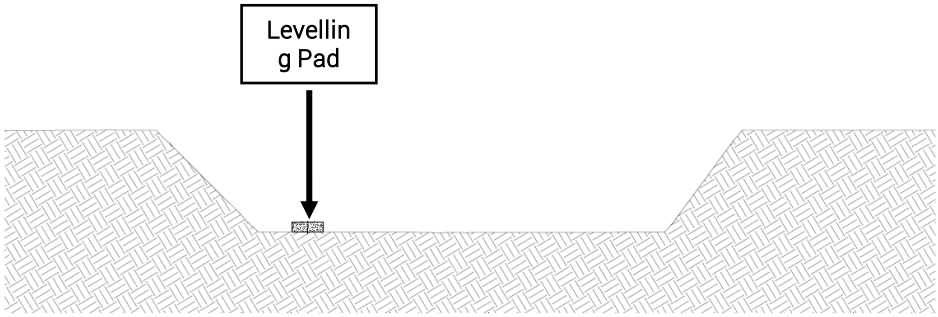

Fig. 5.3 Casting of the levelling pad

2. The lean concrete for the levelling pad which will receive the StrataWall™ EC panels shall be laid. Grade of concrete shall be minimum M-15. Width of the levelling pad shall be according to the Drawing. Thickness of the lean concrete shall not be less than 150mm, however the level of the top of the lean concrete that would receive the first row of panels shall be horizontal and as per the Drawings. The levelling pad shall be discontinuous at the location of the slip joints. Width of the discontinuity shall be according to the Drawings.

3. The top of the levelling pad shall be rendered smooth to ensure intimate and complete contact between the fascia panel and the lean concrete of the levelling pad.

E. Construction of the RS Structure

The StrataWall™ EC system reinforced soil structure shall be constructed with specified QC measures and precautions. Checks are essential at every stage. Outstanding points are highlighted below.

1. Polymeric or elastomeric spacer strips shall be provided along the edges of the panels to ensure that there is no concrete-to-concrete abrasion. The strip will also ensure intimate contact between the panel and the top surface of the levelling pad. As a rule, spacer strips shall be provided in the joints between all panels of he StrataWall™ EC system. Care shall be exercised while placing the wedges to hold the panels in position during erection and backfilling the soil matrix.

Always ensure there should be no concrete-to-concrete abrasion

Fig. 5.4 Spacer strips placed between the panels

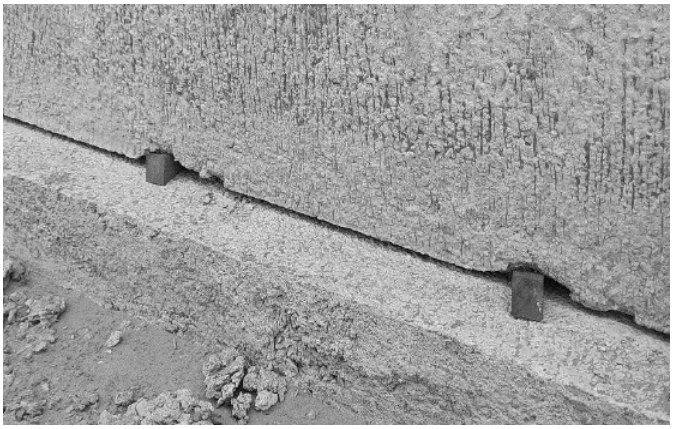

Fig. 5.5 Wooden wedges to hold panels in position

2. For the first row of panels, it is advisable for convenience sake that the bottom-most set of StrataStrip™ geogrids shall be inserted and pulled from within the lower pair of SC connectors. The first row of panels shall be placed in position and aligned in direction and batter.

3. Fig. 5.6 shows the erection of the initial row of panels. The first row is crucial since it sets the trend of aligning the structure, the batter of the front of the structure and the carriage width. Care shall particularly be exercised at curves in the alignment of the carriageway. It would be difficult to rectify any error if the first row of panels is misaligned in any way or off the required carriageway alignment. The first row shall preferably be positioned with the help of struts, scaffolding or templates.

Proper position and alignment of the first row of panels is very Crucial.

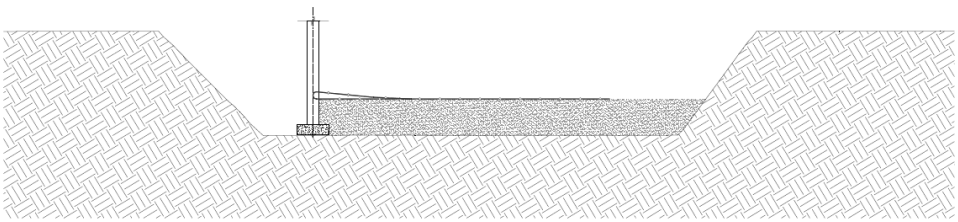

Fig. 5.6 Erection of the initial row of panels

4. As the height and length of StrataWall™ EC progresses, the vertical direction and longitudinal alignments shall be continuously checked. Corrections shall be made immediately on noticing any aberrations during construction.

5. Generally the panels over the length and height of StrataWall™ ECU are adjusted and held in position by wedges and clamps..

6. Fig. 5.7 shows a long boom crane used to help place the panels. While the panels are not heavy, long boom cranes may be preferred to handle the panels to cover areas that are not easily manoeuvrable, such as at foundation levels and when the ramps under construction are not conducive to crane movement.

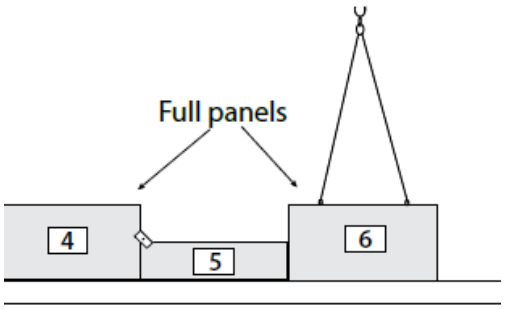

Fig. 5.7 Placing the Panels

7. Soil matrix shall be placed behind the panel and compacted to the first level of geogrids. While a vibratory compacter shall be used to compact the soil matrix, only hand tamping with a light mechanical tamper shall be done within one metre (3 feet) of the panel. It is however preferred that self-compacting material such as gravel be used min. 300mm (1 feet) behind the panel to avoid misaligning the panel in any way. Both reinforcement soil matrix and soil backfill shall be compacted in layers not exceeding compacted thickness of 200mm. Compaction shall be carried out till the materials achieve 97% maximum modified Proctor density. Prior to end of the day's work, it shall be ensured that the last layer of the matrix and backfill are dressed to slope to a temporary drain to route any storm water out of the system, still under construction.

Proper compaction is extremely important for the Success of a Reinforced Soil Wall.

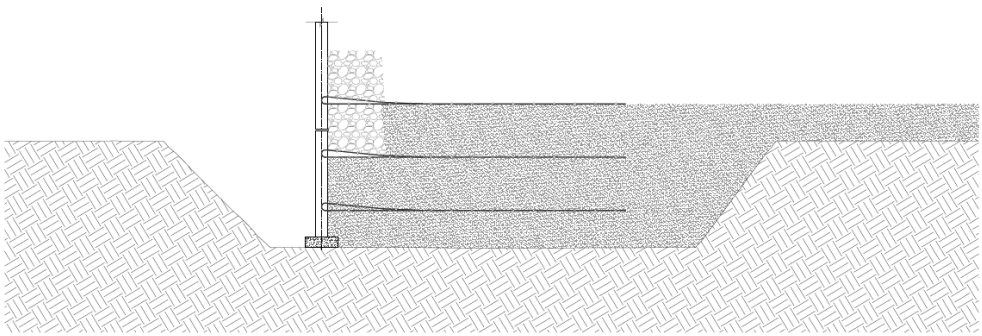

Fig. 5.8 Soil filling layer wise with proper compaction

8. At 1m from the panel, the soil matrix (and also the soil backfill) shall be compacted according to the standard globally observed compaction norms which are not included in this document. The standard quality control practices shall be observed.
9. Other detailing aspects required by the designer and as indicated in the Drawings shall be implemented / constructed. These may include but not be limited to appropriate placement of filtration fabric (nonwoven / woven geotextiles), drainage system, geocomposites etc.
10. The obstructions indicated by the designer that cannot be removed, such as pipes and culverts, in the Drawing. These details shall be strictly followed.

11. Placing of StrataStrip™ geogrid is of prime importance that needs special attention. Considering the length of the reinforcement, StrataStrip™ may be inserted into the SC connectors after the panel is raised into its designated location. After StrataStrip™ reinforcement strips are inserted in the panel, the strips shall be carefully rolled and placed near the respective panel. Thereafter, the panel shall be aligned to its required position

Ensure a strong connection between the Fascia and reinforcement.

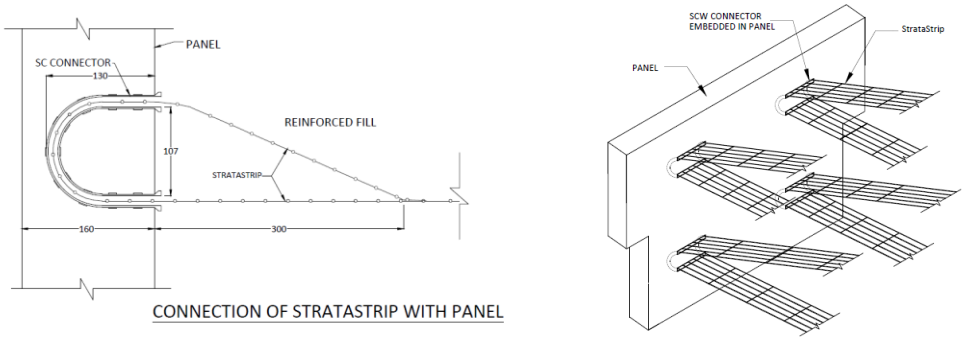

Fig. 5.9 Connection between StrataStrip and Panel

11. The soil matrix shall be placed and compacted with a mechanical hand tamper or a regular vibratory compactor, depending on the distance of compacting the matrix from the panel fascia.

13. Once the compacted soil matrix has reached the level of the SC connectors through which StrataStrip™ have been inserted, the full length of StrataStrip™ shall be unrolled to full length and spread to the angle from the perpendicular from the panel as shown on the Drawing, as shown in Fig. 5.10. StrataStrip™ shall be tugged and stretched to remove any slack in the reinforcement. The reinforcement position will be maintained during placement and compaction of the next layer of the soil matrix by wooden stakes.

Proper placing and fixing of reinforcement is crucial.

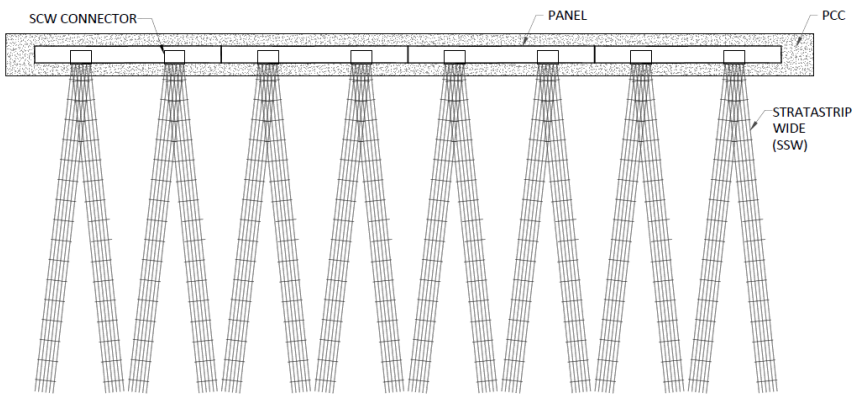

Fig. 5.10 Fixing the StrataStrip's in position

14. Slip Joints:

A break in the structural entity at judiciously designed intervals. These are essentially provided so that any differential behavior of the system does not jeopardize structural integrity or cause serviceability distress. In the case of RS walls, structural segregation is along the length of the structure (e.g. over the length of the ramp which varies in height and can cover several geotechnically diverse subsurface characteristics).

Slip joints are also provided where the designer may deem it necessary to initiate a change in foundation levels along the alignment, by a step.

Each RS wall entity, except the compacted soil matrix and soil backfill, shall be unique on either side of the defined slip joint. This includes the lean concrete levelling course for the panels, the panels, and the crash barriers at the top. The reinforcement from one side of the slip joint shall not be placed into the other side.

Care shall be taken that StrataStrip™ geogrids do not cut across the designated slip joints and do not overlap each other.

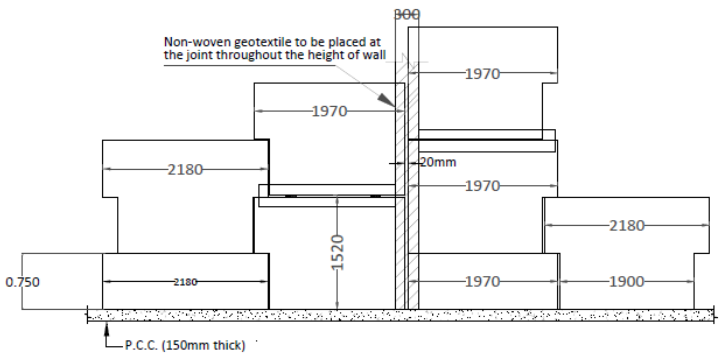

Fig. 5.11 Typical Slip Joint

15. All through the activities of soil matrix placement and compaction, and placement, spreading and aligning StrataStrip™ geogrids, the position and alignment of the panels shall be continuously checked and corrected immediately.

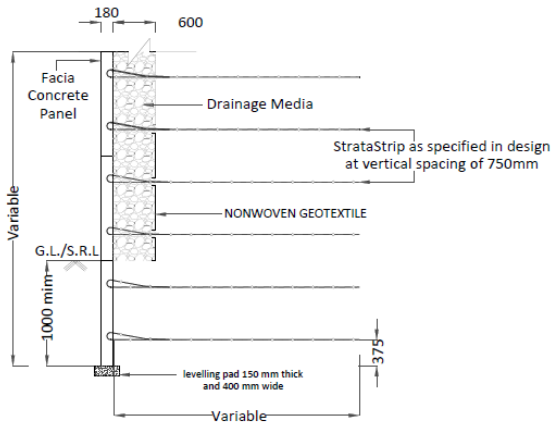

Fig. 5.12 Typical cross section of RS Wall

14. Slip Joints:

A break in the structural entity at judiciously designed intervals. These are essentially provided so that any differential behavior of the system does not jeopardize structural integrity or cause serviceability distress. In the case of RS walls, structural segregation is along the length of the structure (e.g. over the length of the ramp which varies in height and can cover several geotechnically diverse subsurface characteristics).

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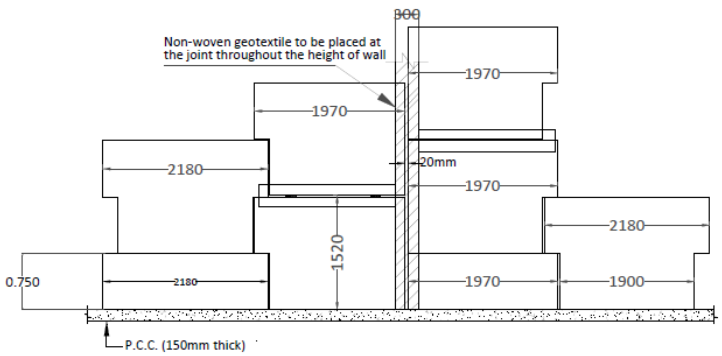

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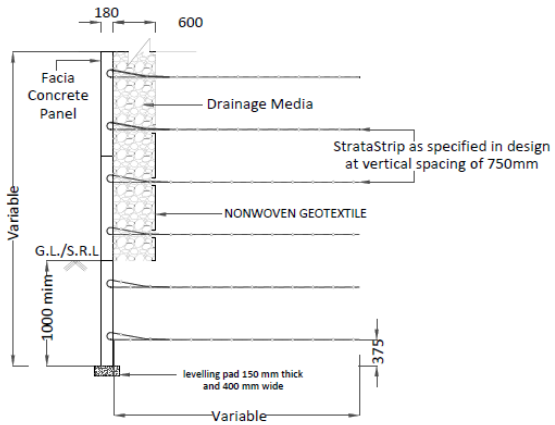

Fig. 5.12 Typical cross section of RS Wall

16. On reaching the requisite height, precast reinforced concrete crash barriers shall be placed atop the StrataWall™ EC panels as shown in Fig. 5.13. During placement of the crash barriers, it shall be ensured that there is a minimum cover of 100mm compacted soil matrix over the uppermost StrataStrip™ geogrid reinforcement. This is to ensure that the StrataStrip™ geogrid is not damaged by the friction slab of the crash barrier while placement. Also, to function effectively, there needs to be a soil base for the crash barrier friction slab.

Protect the top reinforcement with minimum 100mm soil cover.

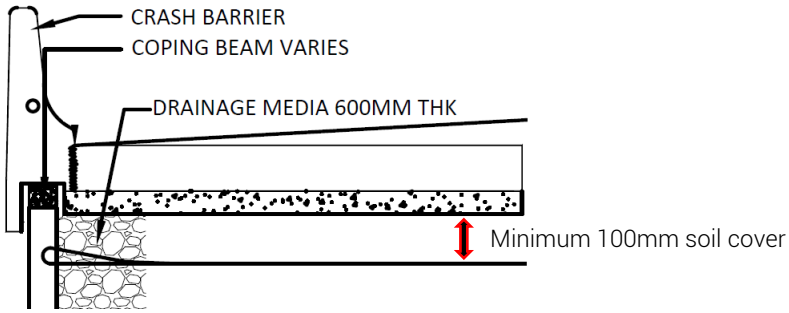

Fig. 5.13 Crash barrier placed

17. Plinth protection to be added outside the wall – to protect against scour, rodents etc.
18. The completed StrataWall™ EU system is shown in Fig. 5.14. The system is thereafter handed over to the Client / Owner for further processing, such as construction of pavement section, medians etc.

Fig. 5.14: The completed StrataWall™ EU system

Thank you

STRATA

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